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Risk Assessment Work Plan
Marine Terminal 1 South
2100 NW Front Avenue
Portland, Oregon

Prepared for
Port of Portland

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RISK ASSESSMENT WORK PLAN
MARINE TERMINAL 1 SOUTH
2100 NW FRONT AVENUE
PORTLAND, OREGON

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1.0 INTRODUCTION AND OBJECTIVES

This baseline risk assessment (RA) work plan (work plan) describes the scope, focus, and approach to evaluate risk to human health and the environment posed by potential exposure to site-related contaminants at Marine Terminal 1 South site (T1 Site) in Portland, Oregon. This work plan has been developed in general accordance with Oregon Administrative Rules (OAR) 340-122-084, Oregon Department of Environmental Quality (DEQ) risk assessment guidance documents (DEQ, 2000) and the "Risk Assessment Guidance for Superfund: Volume 1, Human Health Evaluation Manual" (EPA, 1989), as appropriate.

The general objectives of the RA are to:

- Identify the quantitative risk to human health resulting from releases of chemicals at the T1 Site;
- Perform a Level 1 scoping ecological risk assessment; and
- Prepare a report documenting the results of the above assessments.

These activities are discussed in detail within this work plan.

2.0 SITE DESCRIPTION AND HISTORY

Terminal 1 is the oldest marine facility owned by the Port. Presently, it is divided into two sections: the upstream portion (Terminal 1 – South Complex) and the downstream portion (Terminal 1 – North Complex). Terminal 1 South is presently designated for non-marine use (Port of Portland, 2000). This risk assessment work plan only covers issues related to the Terminal 1 South Complex.

Since 1998, environmental activities have been performed at the T1 Site. These activities have provided a detailed understanding of the site and surrounding vicinity. Results of these activities are discussed in the Remedial Investigation (RI) report for the site (Hahn and Associates, 2001).

Applicable background information for performing the HHRA is presented below. References are provided in Section 6.0.

2.1 Site Location, Description, and History

2.1.1 Site Location

The T1 Site is located at 2100 NW Front Avenue along the Willamette River in Portland, Oregon (Figure 1). The site consists of approximately 21 acres located northwest of Interstate 405 (Fremont Bridge), northeast of NW Front Avenue, southeast of Slip No. 2, and southwest of the Willamette River (Figures 1 and 2). The T1 Site does not include sediments adjacent to the Site.

2.1.2 Site Description

Two primary structures, designated as Warehouse No. 2 and House No. 104, are currently located at the T1 Site. Tristar Transload currently leases and operates the open storage area southeast of Slip No. 2 and northwest of House No. 104 and portions of House No. 104. The remaining portions of the site are unoccupied. Additionally, an extensive dock structure is present over submerged land at Berths 104, 105, and 106.

The topography at the T1 Site is generally level at an elevation of approximately 30 feet above mean sea level (msl). The site is generally paved with asphalt or concrete with little or no vegetation or bare ground present.

2.1.3 Site History

The site history presented here is summarized from information contained in a Preliminary Assessment (PA) (Port of Portland, 2000) prepared for the T1 Site. In approximately 1884, upland areas in the vicinity of Terminal 1 extended 100 to 200 feet northeast of Front Avenue. By 1908, they extended approximately 200 to 400 feet northeast of NW Front Avenue. Since that time, various portions of the T1 Site have been filled and dredged. Slip Nos. 1 and 2 were created by dredging in approximately 1914 and 1923, respectively. Filling activities at the site were generally completed in approximately 1972 when Slip No. 1 was filled.

Between 1913 and 1936, the Commission of Public Docks purchased various parcels of property in four primary phases. Three of these parcels now make up the Marine Terminal 1 South complex. The Commission of Public Docks merged into the Port on January 1, 1971.

Prior to and during World War II, Terminal 1 and the adjacent industrial neighborhood supported expanded activities on behalf of the war effort. Ship building and repair at the Willamette Iron and Steel facility formerly located at Terminal 1 necessitated increased dock front dredging (for larger ship berths) and the occasional use of Terminal 1 property for temporary equipment storage.

In 1946, the Commission of Public Docks (CPD) purchased the Eastern and Western Lumber Company property to the immediate north of Terminal 1 South. Willamette Iron & Steel Corporation, now adjacent to the CPD terminal, changed ownership in the same year, becoming the Willamette Iron and Steel Company.

Historically, Terminal 1 has been used for the staging of lumber, logs, paper products, steel containers, and bagged grain. Various companies have owned or leased portions of the Terminal 1 South Complex (see RI Report; Hahn and Associates, 2001). The T1 Site will be redeveloped for residential and commercial purposes.

2.2 Site Geology and Hydrogeology

This section presents a summary of the site geology and hydrogeology. Additional details of site geology and hydrogeology are presented in the RI Report (Hahn and Associates, 2001).

2.2.1 Geology

- The subsurface soils encountered during the investigations were predominantly sands and silts with occasional gravel to the maximum depth of investigation at 80 feet below ground surface (bgs).
- Based on historical documentation and investigations, the property has been extensively filled-in through time; fill material was encountered at all push-probe locations from the surface to depths of 32 to 67 feet bgs.
- Soils thought to be former Willamette River sediments were encountered at the former Slip No. 1 (B-84) at a depth of approximately 67 feet bgs.
- Soils encountered beneath NW Front Avenue were generally siltier than those encountered on the T1 Site, suggesting the soils in the right of way are either alluvial in origin or from a different fill source than that of the site.

2.2.2 Hydrogeology

- Groundwater in the vicinity of the T1 Site generally occurs in three principal hydrogeologic zones: (1) a shallow unconfined fill/alluvial deposit (shallow water-bearing zone [WBZ]); (2) generally confined Troutdale WBZ; and (3) the confined Columbia River Basalt WBZ.
- Unconfined groundwater was encountered within the shallow WBZ (fill) at an average depth of approximately 23 feet bgs.
- Direct measurement of groundwater flow direction and hydraulic gradients has not been conducted at the T1 Site; however, based on sites similarly located along the Willamette River, it would be expected that groundwater within the Shallow WBZ is hydraulically connected to the Willamette River, with groundwater flow beneath the Site to the northeast.

2.3 Beneficial Land and Water Use

Beneficial land and water use determinations were completed at the T1 Site to identify current and reasonably likely future uses of land and water in the vicinity of the Site. This information was presented in the RI Report (Hahn and Associates, 2001) and used to ensure that appropriate exposure scenarios were selected for evaluation in the proposed RA.

2.3.1 Locality of the Facility

The locality of the facility (LOF) is defined as "any point where a human or ecological receptor contacts, or is reasonably likely to come into contact with, facility related hazardous substances." The LOF requires more than just the presence of constituents at a particular location; there must also be a reasonable possibility for a receptor to come into contact with the constituents for locality to exist.

Chemicals have been detected in both soil and groundwater at various areas of the site, but off-site migration of contamination is not evident based on the existing data. Accordingly, the LOF is defined only as the T1 Site.

2.3.2 Land Use

Historical Land Use. The approximate 21-acre T1 Site has historically been zoned as "IH" for Heavy Industrial. Surrounding adjacent properties are zoned "IH" Heavy Industrial and "EX" Central Employment.

Current and Reasonably Likely Future Land Use. The current and reasonably likely future land use in the LOF is well defined. The site is currently zoned as Central Residential (RX) such that it can be redeveloped for an alternative use. The RX zoning is considered the comprehensive plan for the property. Based on the RX zoning designation, it is expected the site will be used for mixed-use residential/commercial development in the future.

2.3.3 Groundwater Beneficial Use

A beneficial groundwater use evaluation was conducted for the Hoyt Street Property (RETEC, 1997) that adjoins the southeast corner of the T1 Site. Hahn and Associates conducted an additional well inventory as part of the RI to supplement the RETEC survey. Based on trends in groundwater use in the area as well as RETEC fate and transport modeling, the only identified beneficial use for groundwater in the LOF is discharge to the Willamette River. No surface water rights were identified within one-half mile of the T1 Site.

2.4 Site Investigations

In July 2001, Hahn and Associates completed an RI at the T1 Site (Hahn and Associates, 2001). RI activities completed at this site consisted of the following five phases:

- Focused Environmental Site Assessment completed by Maul Foster in 1998 (Maul Foster, 1998);
- Environmental Baseline Investigation completed by Hahn and Associates in February and March, 2000 (Hahn and Associates 2001);
- B-38 Area Characterization completed by Hahn and Associates in March 2000 (Hahn and Associates 2001);
- Supplemental Site Characterization Activities completed by Hahn and Associates in September 2000 (Hahn and Associates 2001); and
- Data Gap Investigation completed by Hahn and Associates during October and November 2000 (Hahn and Associates 2001).

A total of 112 push-probe borings were installed for the collection of soil and groundwater samples during these site activities. The locations of these push-probe borings are presented on Figure 2. Please refer to the RI Report (Hahn and Associates, 2001) for further discussion of these activities and results.

2.5 Contaminants of Potential Concern

Based on investigations conducted at the T1 Site, the contaminants of interest (COIs) in soil and groundwater include the following groups of compounds: Total Petroleum Hydrocarbons (TPH), polycyclic aromatic hydrocarbons (PAHs), volatile organic compounds (VOCs), polychlorinated biphenyls (PCBs), and metals. A conservative preliminary screening of COIs was conducted as part of the RI using EPA Region 9 residential soil and tap water preliminary remediation goals (PRGs; EPA, 2000) and DEQ Ecological Benchmark Screening Levels (for groundwater only) to identify preliminary Contaminants of Potential Concern (COPCs) in soil and groundwater. If the maximum detected concentration of a chemical at the site exceeded the screening level, then that chemical was retained as a preliminary COPC.

The preliminary COPCs identified for the site soils and groundwater include the following chemicals:

Semivolatile Organic Compounds

benzo(a)anthracene
benzo(a)pyrene
benzo(b)fluoranthene
benzo(k)fluoranthene (groundwater only)
dibenzo(ah)anthracene
indeno(1,2,3-cd)pyrene
phenanthrene (groundwater only)
DEHP (groundwater only)

Metals

arsenic
copper (groundwater only)
lead

Final COPCs will be identified in the RA following the Contaminant Screening Procedures presented in Section 2.3.2 of DEQ's risk assessment guidance (DEQ, 2000).

2.6 Nature and Extent of Contamination

The RI Report for this site presents detailed information on the results of soil and groundwater sampling conducted at the T1 Site (Hahn and Associates, 2001). This section briefly summarizes conclusions of the RI regarding petroleum hydrocarbons and metals in soil and groundwater. Please refer to

the RI Report for additional details of the site investigation and discussion of the nature and extent of contamination found at this site.

The analysis of soil samples for TPH and PAHs found six general areas/locations of soil impacted with petroleum hydrocarbons. These areas are identified as the B-5 Area, B-20 Area, B-29 Area, Dry Well (B-37) Area, B-38 Area, and the B-102 Area, as shown on Figure 2. In addition, TPH and PAHs were detected in a deep soil boring (B-84 at a depth of 67.5 bgs) completed in the former location of Slip 1.

Arsenic and lead were detected in soil samples above their corresponding PRGs. The RI report states the majority of the arsenic concentrations detected in soil are at background levels. Arsenic was detected in soil above the established site-specific background level of 5.3 ppm at three areas of the site: Borings B-3 and B-11, and in the B-38 Area. Please refer to the RI Report for additional details of this evaluation (Hahn and Associates, 2001). Lead was only detected in the B-38 Area at concentrations exceeding the corresponding PRG. The elevated concentrations of lead in soil appear to correspond to areas of elevated concentrations of petroleum hydrocarbons in soil.

Analytical testing of groundwater samples conducted during the RI indicates PAHs were detected at concentrations above screening levels in the B-37 (dry well) and B-38 Areas. Bis(2-ethylhexyl)phthalate (DEHP) was detected at concentrations exceeding screening levels at GW-1 and GW-4 at the southern portion of the site. Arsenic was detected in groundwater above the tap-water PRG in the B-38 Area and at GW-1, GW-4, and GW-6. Copper was detected at a concentration exceeding the DEQ ecological screening value in the B-38 Area. Lead was detected in groundwater above the DEQ ecological screening value at GW-6 and GW-7. Please refer to Figure 2 for sampling locations and Area designations.

The RI Report states the source of DEHP in the groundwater samples are assumed to be from either laboratory and/or equipment contamination, and, therefore, DEHP will not be further considered as a groundwater COPC for this site. Please refer to the RI Report for additional details of this analysis (Hahn and Associates, 2001).

3.0 HUMAN HEALTH RISK ASSESSMENT

This section describes the scope, focus, and approach for the human health risk assessment (HHRA) for the site. This risk assessment will conform to

the protocol for performing risk assessments under OAR 340-122-084 and DEQ's Guidance for Conduct of Deterministic Human Health Risk Assessments
(DEQ, 2000). Other guidance will be used as appropriate and where indicated. The HHRA will evaluate the probability and magnitude of adverse impacts on human health associated with actual or potential exposure to site-related COPCs. This information will be used to determine what additional remedial actions are needed (if any) to mitigate any predicted impacts. Deterministic human health risk assessments for both existing and reasonably likely future exposure scenarios will be performed.

The proposed human health risk assessment will quantitatively evaluate the complete exposure pathways identified in the preliminary conceptual site model developed for the site (Figure 3). In accordance with EPA and DEQ guidance, the risk assessment will consist of the following four phases: Exposure Assessment, Toxicity Assessment, Risk Characterization, and Uncertainty Analysis. In the exposure assessment, current and future land use scenarios will be developed based on the conceptual site models developed for this site. Exposure point concentrations (EPC) and reasonable maximum exposure (RME) and central tendency (CT) intake rates will be developed for each complete exposure pathway based on the use of exposure factors that reflect site-specific conditions.

In the toxicity assessment, quantitative toxicity information will be collected, and appropriate toxicity values will be determined for use in quantifying carcinogenic and non-carcinogenic risks associated with exposure to site-related chemicals. In the risk characterization phase, the results of the exposure assessment and toxicity assessment will be combined to estimate the potential cancer risks and non-cancer hazard quotients at the site. In the uncertainty section, the uncertainty associated with the exposure assessment, toxicity assessment, and risk characterization sections will be discussed.

3.1 Exposure Assessment

The objectives of an exposure assessment are to:

- Identify potentially exposed populations;
- Identify potentially complete exposure pathways; and
- Measure or estimate the magnitude, duration, and frequency of exposure for each receptor (or receptor group).

3.1.2 Preliminary Conceptual Site Model

The preliminary conceptual site model (CSM) is based on an evaluation of existing data and the current and reasonably likely future conditions at the site (Figure 3). This model provides the framework for assessing potential exposure pathways to be considered in the risk assessments.

To be considered complete, an exposure pathway must have: (1) an identified source of COPCs; (2) a release/transport mechanism from the source; and (3) a receptor to whom contact can occur. At this site, likely or potential sources include former USTs, former ASTs, machine shop areas, paint/battery/waste oil/drum/chemical storage, railroad spur, and miscellaneous spills and leaks.

Potentially Exposed Populations. A beneficial land and water use survey has been completed for the site (Hahn and Associates, 2001). Based on the Central Residential (RX) zoning designation, it is expected the site will be used for mixed-use residential/commercial development in the future. The only identified beneficial use for groundwater in the locality of the facility is discharge to the Willamette River. No surface water rights were identified within one-half mile of the T1 Site.

Therefore, the preliminary CSM presented in this work plan assumes the future area land use will be a mix of residential and commercial and that groundwater beneath the site is not and likely will not be used for drinking water. Figure 3 presents the preliminary CSM for this site. Check marks on the figure indicate potentially complete pathways to the indicated receptor. In addition to residential and commercial receptors, the HHRA will also evaluate utility/excavation workers as potentially exposed populations.

Potentially Complete Exposure Routes. Exposure pathways for quantitative analysis were selected based on the preliminary CSM developed for this site. Based on available information, the exposure pathways to be evaluated for receptors in this human health risk assessment are:

- Incidental ingestion of soil (all receptors);
- Direct contact with soil (all receptors);
- Inhalation of particulates from surface soil (all receptors); and
- Inhalation of VOCs from soil and groundwater (all receptors; indoor and outdoor air for commercial and residential receptors; outdoor air only for utility/excavation workers).

Direct contact with groundwater is not considered a potential exposure pathway for utility/excavation workers as the average depth of the shallow WBZ was reported to be 23 feet bgs (Hahn and Associates, 2001).

Areas of Concern. The T1 Site is being redeveloped for residential and commercial purposes. The site will be developed into three areas (A, B, and C) which will be evaluated as separate areas of concern (AOCs). Separate risk calculations and risk estimates will be conducted for each AOC. The RI identified six general areas/locations of soil impacted with petroleum hydrocarbons. Area of Concern A includes the B-20 Area, B-38 Area, and B-102 Area. Area of Concern B includes the B-5 Area, B-29 Area, and B-37 (Dry Well Area). Area of Concern C does not include any areas/locations of soil impacted with petroleum hydrocarbons. The proposed AOCs for this site are presented on Figure 2.

3.1.2 Development of Exposure Point Concentrations

Exposure point concentrations (EPCs) represent the chemical concentrations in the soil and groundwater that the receptor will potentially contact during the exposure period. The EPCs for the site's COPCs will be derived from either data obtained from sampling or from a combination of sample data and fate and transport modeling. For example, air EPCs will be modeled from soil and/or groundwater EPCs for volatile constituents. Groundwater data from monitoring well samples collected in September 2001 will be used to represent current and future groundwater conditions.

The residential and commercial worker scenarios will be evaluated based on exposure to surface soil (0 to 3 feet bgs), while the utility/excavation worker scenario will be based on exposure to surface and subsurface soil (0 to 15 feet bgs). However, if VOCs are identified as soil COPCs, all soil down to groundwater will be considered in the volatilization to indoor and outdoor air pathways.

In accordance with EPA guidance (EPA, 1989) for chemicals detected at one sampling location but not at others, a proxy concentration equal to half the sample quantification limit (SQL) will be used to represent the concentration of the chemical of concern in a sample where it is not detected.

The 90 percent upper confidence limit (UCL) on the arithmetic mean concentration of COPCs in each environmental medium of concern will be used to evaluate the reasonable maximum exposure (RME) scenario, while the arithmetic mean will be used to evaluate the central tendency (CT)

exposure scenario (EPA, 1989). The RME scenario is intended to be a conservative estimate of potential exposure, while the CT exposure scenario is intended to be a more realistic exposure scenario. Using both the RME and CT allows for a range of potential risk and hazard estimates. The 90 percent UCL is calculated based on EPA (1992) guidance. The manner of calculating the 90 percent UCL will be as follows:

- As a first step, the underlying distribution of the data will be evaluated using the Shapiro and Wilk W-Test (Gilbert, 1987) to determine if the data are normal or lognormal. If the normal and lognormal distributions are indicated, the 90 percent UCL will be calculated appropriately.
- If the normality test rejects both normal and lognormal distributions at a significance level of 95 percent, the test will be rerun by adjusting the W-Test quantile downward by 0.1 from the original quantile (providing a greater tolerance for accepting a distribution). If the data set conforms to a normal or lognormal distribution with the greater tolerance, the distribution will be reported as weak lognormal (or weak normal).
- If the normal and lognormal distributions are rejected with the greater tolerance, the data will be assumed to fit a lognormal distribution for calculation of the 90 percent UCL (assumed lognormal distribution; EPA, 1992).
- In cases where the 90 percent UCL or the calculated mean concentration exceed the maximum detected value (which can occur in data sets with a large variance), the maximum detected value will be used to define the upper limit of this range.

The inhalation of particulates and VOCs pathways will be evaluated using the fate and transport models presented in DEQ's risk assessment guidance (DEQ, 2000) and risk-based decision-making guidance (DEQ, 1999).

3.1.3 Exposure Factors

To quantitate intake estimates for site-related chemicals, EPCs are combined with variables that describe the exposed population (e.g., contact rate, exposure frequency and duration, body weight). Exposure factors will be selected using standard default exposure factors presented in Guidance for Conduct of Deterministic Human Health Risk Assessments (DEQ, 2000). Industrial exposure assumptions will be used to evaluate the commercial scenario.

The following paragraphs describe the exposure pathways proposed for evaluation in this HHRA.

Incidental Soil Ingestion. Incidental ingestion of soil is often a primary route of exposure to particulate-bound chemicals. Individuals have been observed to ingest small amounts of soil as a result of hand-to-mouth behavioral patterns that may follow soil contact activities. RME and CT factors applicable to this pathway for the identified human receptors are summarized in Table 1.

Dermal Soil Contact and Absorption. In addition to leading to incidental soil ingestion, soil contact can also result in absorption of some chemicals directly through the skin. RME and CT exposure factors for the dermal contact pathways are summarized in Table 2. Dermal absorption rates have not been well defined in the available literature. Current RME and CT dermal absorption factors will be selected from DEQ Human Health Risk Assessment Guidance (DEQ, 2000).

Air Inhalation. Exposure to chemicals present in soil and groundwater may also result from inhalation of vapors and/or particulates generated at the site. RME and CT factors applicable to this pathway are summarized in Tables 3 and 4.

3.2 Toxicity Assessment

The objectives of the toxicity assessment are to evaluate the inherent toxicity of the compounds under investigation and to identify and select toxicological measures for use in evaluating the significance of the exposure. These toxicological measures or criteria will be used in conjunction with intake rates for chemicals of concern in the risk characterization process of the human health risk assessment.

Standard human health risk assessment toxicity databases will be used to derive health-based toxicity criteria. The hierarchy of sources for toxicity criteria for use in this risk assessment will follow that presented in OAR 340-122-084. The hierarchy of toxicity criteria is as follows:

(1) EPA's Integrated Risk Information System (IRIS);

(2) EPA's Health Effects Assessment Summary Table (HEAST);

(3) EPA-NCEA Superfund Health Risk Technical Support Center;

(4) Other U.S. EPA documents or databases;

(5) ATSDR minimal risk levels (MRLs); and

(6) Other professionally peer-reviewed documents as needed and as approved by DEQ.

3.2.1 Types of Toxicity Values for Quantifying Risks

Toxicity and risk assessments vary for different chemicals depending upon whether non-carcinogenic or carcinogenic responses (i.e., endpoints) are used to assess potential risks. These criteria, in turn, are based on the endpoints observed from laboratory or epidemiological studies with the chemicals. Some chemicals of concern may result in both non-carcinogenic and carcinogenic effects, although in many cases the EPA has published toxicity criteria for only the most sensitive type of toxic effect supporting the most restrictive toxicological criteria.

Reference Doses (RfDs). Reference doses are used to quantitatively evaluate non-carcinogenic toxicity of a specific chemical. Reference doses are established at levels associated with no adverse effect—the "no observed adverse effect level" (NOAEL). In general, the RfD is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime.

RfDs are developed from an analysis of the available toxicological literature from which a critical study is selected. The selection of a critical study is made by professional judgment and considers factors such as the quality of the study, the relevance of the study to human exposures, and other factors. Good quality human toxicological data are preferred to animal studies. If human data are not available, the study on the most sensitive species is selected as the critical study. Similarly, the toxic effect manifested at the lowest exposure level is (generally) selected as the critical effect.

Cancer Slope Factors (SFs). The toxicity of potential human carcinogens is evaluated differently. It is assumed for carcinogens that no threshold concentrations exist below which adverse effects may not occur. Probabilistic methods based on chemical-specific dose-response curves are used to establish slope factors, which are then used to quantify potential risks from exposure to carcinogens.

Dose-response curves are generated in laboratory studies using high chemical concentrations. The dose-response curve is fitted to a linearized multistage model that extrapolates the slope of the curve from high

experimental concentrations to low concentrations at which people are typically exposed. The final slope factor (SF) is based on the 95 percent UCL of the extrapolated slope of the dose-response curve. Because of the non-threshold assumption and the UCL statistical procedure, the use of published slope factors provides a conservative upper-bound estimate of potential risks associated with exposure.

3.2.2 Modification of Oral Toxicity Values for Evaluating Dermal Exposure

Oral toxicity values are expressed as administered doses. When evaluating dermal exposure to contaminants from soil and water, it is necessary to adjust the oral toxicity value (which is based on an administered dose) to one based on an absorbed dose using a chemical's oral absorption efficiency. However, according to EPA guidance (1999, 2000), the only chemical for which an adjustment is recommended at this time is cadmium. Adjustment is not recommended for other chemicals because a scientifically defensible database does not exist for making the adjustment. Therefore, in this HHRA, because cadmium is not a COI at this site, no adjustments of oral toxicity factors to evaluate dermal exposure will be done.

3.2.3 Toxicity Assessment for Lead

Lead is a unique chemical in its pharmacokinetic and toxicological properties. Although classified as both a potential carcinogen (B2 weight of evidence) and a non-carcinogen, lead is most often assessed as a non-carcinogen only, since these effects manifest themselves at doses lower than those for carcinogenicity. However, in contrast to the assumption of the existence of a threshold for non-carcinogenic responses, there does not appear to be a threshold below which lead does not exert a response.

Currently, the EPA provides neither a reference dose for evaluating the non-carcinogenic effects (unrelated to cancer) nor a slope factor for evaluating the carcinogenic effects for lead. EPA has developed an exposure model for lead that considers both its biokinetics and toxicological properties. This model—the "Integrated Exposure Uptake and Biokinetic" (IEUBK) model—integrates the intake of lead from multiple sources, including soil, food, and water ingestion, inhalation, and, when appropriate, maternal contributions. Intakes are assessed for children from ages 0 (birth) to seven. The model does not assess lead intakes for older children or adults. Childhood exposure to lead is the focus of this model because this receptor group is recognized as the most sensitive to the non-carcinogenic effects of inorganic

lead. Therefore, to evaluate lead exposures at the T1 Site, we will use other criteria as described below.

Soil exposures at the site are limited to residents and commercial workers contacting soil at the ground surface or utility/excavation workers contacting soil during trenching or excavation activities. We propose screening the soil lead concentrations against the EPA Region 9 residential soil PRG for lead (400 mg/kg) to evaluate residential exposure and the adult soil screening level for lead (1,000 mg/kg) recommended in DEQ's RBDM Guidance when evaluating commercial and utility/excavation exposures. The HHRA will provide a more detailed discussion of this evaluation.

Lead has been detected in groundwater at the site. However, as lead is not volatile and no direct contact exposure pathways have been identified to human receptors, lead in groundwater will not be further evaluated in the HHRA.

3.2.4 Toxicity Assessment for Total Petroleum Hydrocarbons (TPH)

Determining appropriate toxicity values for TPH (a class of compounds identified as a COI at this site) is difficult because of the characteristics of TPH. TPH are a complex mixture of hundreds or more individual alkanes, cycloalkanes, alkenes, aromatics, and other petroleum substances. For this HHRA, the human health risks associated with TPH will be evaluated using an indicator approach. The indicators refer to single compounds within TPH known or believed to be carcinogenic and non-carcinogenic and which are evaluated individually. The indicator compounds that will be quantitatively evaluated in this HHRA are:

- **Volatiles (BTEX):** benzene, toluene, ethylbenzene, and xylene; and
- **Polynuclear Aromatic Hydrocarbons (PAHs):** anthracene, acenaphthene, benzo(a)pyrene, pyrene, naphthalene, chrysene, ideno(1,2,3-cd)pyrene, benzo(k)flouranthene, flourene, naphthalene, benzo(b)flouranthene, benzo(a)anthracene, and dibenzo(a,h)anthracene.

3.3 Risk Characterization

Risk characterization is the process of comparing the chemical intake by a receptor to the toxicity of the chemical. This comparison is expressed either as a hazard index (non-carcinogens) or an excess lifetime risk of cancer (carcinogens). Potential risks and hazards will be calculated using the Intake Method or the RBC Method, depending on the exposure pathway being

evaluated. These two methods for completing the risk characterization are described in Section 3.3.1 and 3.3.2.

3.3.1 Intake Method

Soil ingestion, dermal contact with soil, and inhalation of particulates and volatiles from surface soil will be evaluated using the intake method described below.

Non-Carcinogenic Effects. For the residential exposure pathway, the non-carcinogenic intakes are based on child exposures, which are more conservative than potential adult exposures. The daily intake of each compound resulting from site exposure is divided by the available RfD value for the compound to compute a hazard quotient (HQ), as follows:

$$HQ = CDI/RfD$$

where:

CDI = Chronic daily intake; the estimated exposure level over a given time period in mg/kg-day.

RfD = Reference Dose; the exposure level that is likely to be without deleterious effects during a given time increment in mg/kg-day. Only chronic RfDs were used for this risk assessment.

Carcinogenic Effects. For the residential exposure pathway, the carcinogenic intakes are based on combined adult and child exposures, which are more conservative than child or adult exposures calculated separately. An estimated excess lifetime cancer risk is calculated using:

$$Risk = CDI \times SF$$

where:

CDI = Chronic daily intake; the estimated lifetime exposure level in mg/kg-day.

SF = Slope Factor; the upper-bound estimate of the probability of a cancer response per unit of intake of a chemical over a lifetime, expressed as $(mg/kg\text{-}day)^{-1}$.

3.3.2 RBC Method

Inhalation of volatiles that have migrated from soil and/or groundwater *in situ* to outdoor and indoor air will be evaluated using the RBC Method described below.

Non-Carcinogenic Effects. For the residential exposure pathway, the non-carcinogenic intakes are based on adult exposures. The use of adult receptors in evaluating these exposure pathways is consistent with DEQ's RBDM guidance. For each non-carcinogen, the EPC is divided by the non-carcinogenic RBC to compute a hazard quotient (HQ) as follows:

$$Hazard\ Quotient = EPC/RBC$$

where:

EPC = Exposure point concentration.

RBC = Risk-based concentration. The RBCs are calculated based on a Hazard Quotient of 1.

Carcinogenic Effects. For the residential exposure pathway, the carcinogenic intakes are based on combined adult and child exposures, which are more conservative than child or adult exposures calculated separately. For each carcinogen, the EPC is divided by the carcinogenic RBC, then multiplied by the acceptable risk level of 1×10^{-6} to compute the risk estimate as follows:

$$\text{Risk} = (\text{EPC}/\text{RBC}) \times (1 \times 10^{-6})$$

where:

EPC = Exposure point concentration.

RBC = Risk-based concentration. These RBCs are calculated based on a cancer risk level of 1×10^{-6}.

3.3.3 Cumulative Hazard and Risk Estimates

For simultaneous exposure to multiple chemicals with similar toxic effects or target organ, a Hazard Index (HI) is calculated as the sum of chemical-specific HQs. A toxic effect is considered possible if a HI or HQ exceeds 1 (OAR 340-122-115).

For simultaneous exposure to multiple chemicals, individual risk estimates are summed to provide pathway, media, and receptor total risk estimates. Combining potential cancer risks as a result of exposure to multiple chemicals through multiple exposure pathways assumes the following:

- Exposure to all COPCs will result in the same effect (cancer); and
- Each COPC exerts its effect independently (i.e., there is no synergism or antagonism).

OAR 340-122-115 considers 1×10^{-6} and 1×10^{-5} to be acceptable risk levels for individual and multiple carcinogens, respectively.

3.4 Uncertainty Analysis

It is important to fully specify the assumptions and uncertainties inherent in the risk assessment to place the risk estimates in proper perspective. For

this risk assessment, the general sources of uncertainty to be addressed include:

- Data collection and evaluation;
- Exposure assessment and scenarios;
- Toxicity assessment; and
- Risk characterization.

4.0 ECOLOGICAL RISK EVALUATION

The ecological risk assessment (ERA) will evaluate the probability and magnitude of adverse impacts on the environment associated with actual or potential exposure to site-related compounds. The first step of an ERA is a scoping ERA to determine whether additional ERA activities are warranted at a site.

4.2.1 Level 1 Scoping Ecological Risk Assessment

A Level 1 Scoping Ecological Risk Assessment (Scoping ERA) will be performed in accordance with the document entitled Guidance for Ecological Risk Assessment, Level 1-Scoping (DEQ, 1998). A Scoping ERA is designed to provide a conservative qualitative determination of whether there is any reason to believe ecological receptors and/or exposure pathways are present or potentially present at or in the locality of the site. A Scoping ERA is intended to identify sites that are obviously devoid of ecologically important species and habitats and/or where exposure pathways are incomplete (DEQ, 1998). The Scoping ERA also includes a search for threatened and endangered species.

Scoping ERA Field Work. The Scoping ERA will be performed by a biologist who has experience performing field surveys. The biologist will survey the site by walking the entire property. The field surveys will follow DEQ guidance (DEQ, 1998). The field biologist will use Attachments 1 and 2 of the guidance document as the basis for the Scoping ERA.

Modified Ecological Risk Screening. If any exposure pathways of concern are identified for ecological receptors at the T1 Site based on the results of the Level 1 – Scoping ERA, a modified Level 2 – Screening ERA will be completed. Similar to the human health risk screening, the maximum detected concentration of compounds of interest will be compared against appropriate DEQ Ecological Screening Benchmarks Values. This screening will be conducted to evaluate whether there are contaminants present at this site at levels of potential concern for ecological receptors. This screening will also be completed to establish a preliminary set of ecological COPCs for this

site. If all of the maximum detected concentrations of COIs are below ecological screening values for any identified exposure pathways of concern, it will be concluded that no further ecological risk assessment activities are warranted at the site.

5.0 REPORTING

Hart Crowser will prepare a risk assessment report presenting the results of the human health risk assessment and the scoping ecological risk assessment. Specifically, the report will cover the following major topics:

- Identification of chemicals of potential concern;
- Human exposure model;
- Human exposure assessment;
- Human toxicity assessment;
- Human health risk characterization;
- Ecological scoping assessment; and
- Uncertainties.

The report will be prepared as draft and final submissions. The ecological assessment section will follow the format described in Attachment 3 of the Level 1 ecological guidance document (DEQ, 1998), including results of the data review, field survey, and evaluation of receptors and pathways. Recommendations will be made based on the flowcharts found in the guidance document. Backup documentation will be included as an appendix.

6.0 REFERENCES

DEQ, 1998. Guidance for Ecological Risk Assessment: Level I Scoping, Final. November 1998.

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EPA, 1989. Risk Assessment Guidance for Superfund: Volume 1, Human Health Evaluation Manual, No. 9285.701A. Office of Solid Waste and Emergency Response, Washington, DC.

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Port of Portland, 2000. Preliminary Assessment, Port of Portland Terminal 1, 2200 NW Front Street, Portland, Oregon, 97209. September 18, 2000.

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Table 1 - Exposure Dose Equations and Exposure Factor Values
Soil Ingestion
Terminal 1 South Risk Assessment Work Plan
Portland, Oregon

$$LADD^{a}(mg/kg\text{-}d) = \frac{C_{soil} \times IRS \times CF \times EF \times ED}{BW \times At_{carc}}$$

$$ADD^{b}(mg/kg\text{-}d) = \frac{C_{soil} \times IRS \times CF \times EF \times ED}{BW \times At_{non}}$$

EXPOSURE FACTOR (units)			RME Value	CT Value
C_{soil}	=	Chemical concentration in soil (mg/kg)	UCL_{90}[c]	Arithmetic Mean
CF	=	Conversion factor (kg/mg)	10^{-6}	10^{-6}
IRS	=	Incidental Soil Ingestion Rate (mg/d)		
		Commercial Worker	100[d]	50[d]
		Utility/Excavation Worker	480[d]	100[d]
		Resident – Adult	100[d]	50[d]
		Resident – Child	400[d]	100[d]
EF	=	Exposure frequency (days/year)		
		Commercial Worker	250[d]	250[d]
		Utility/Excavation Worker	9[d]	9[d]
		Resident – Adult/Child	350[d]	40[d]
ED	=	Exposure duration (year)		
		Commercial Worker	25[d]	6[d]
		Utility/Excavation Worker	1[d]	0.5[d]
		Resident – Adult	30[d]	9[d]
		Resident – Child	6[d]	6[d]
BW	=	Body weight (kg)		
		Adult	70[d]	70[d]
		Child	15[d]	15[d]
AT_{carc}	=	Averaging time for carcinogens (days)	25,550[d]	25,550[d]
AT_{non}	=	Averaging time for noncarcinogens (days)	ED (years) x 365 days/year	ED (years) x 365 days/year

Data\Jobs\Port of Portland\15191-00 T-1 Risk Assessment [Table1Soil-Ing(T1)]

Notes:

[a] LADD = Lifetime average daily dose, the intake value used to evaluate potential carcinogenic effects. For the residential evaluation, the adult and child intakes will be combined as recommended in Appendix A, Section A.0 of DEQ guidance (2000).

[b] ADD = Average daily dose, the intake value used to evaluate potential noncarcinogenic effects.

[c] UCL_{90} = An upper one-sided 90 percent confidence limit of the mean or the maximum concentration (whichever is lower) will be used for the RME.

[d] DEQ (December 2000).

RME Reasonable maximum exposure; CT Central Tendency

Table 2 - Exposure Dose Equations and Exposure Factor Values

Dermal Contact with Soil
Terminal 1 South Risk Assessment Work Plan
Portland, Oregon

$$LADD^{a}\ (mg/kg\text{-}d) = \frac{C_{soil} \times AF \times SA \times DAF \times EF \times ED \times CF}{BW \times At_{carc}}$$

$$ADD^{b}\ (mg/kg\text{-}d) = \frac{C_{soil} \times AF \times SA \times DAF \times EF \times ED \times CF}{BW \times At_{non}}$$

Exposure Factor (units)			RME Value	CT Value
C_{soil}	=	Chemical concentration in soil (mg/kg)	UCL_{90}[c]	Arithmetic Mean
AF	=	Soil-to-skin adherence factor (mg/cm^2-event)		
		Commercial Worker	0.08[d]	0.08[d]
		Utility/Excavation Worker	1.0[d]	0.3[d]
		Resident – Adult	0.08[d]	0.08[d]
		Resident – Child	1.0[d]	0.3[d]
SA	=	Skin surface area (cm^2/day)		
		Commercial Worker	4100[d]	3200[d]
		Utility/Excavation Worker	4100[d]	3200[d]
		Resident – Adult	6900[d]	5200[d]
		Resident – Child	5000[d]	4500[d]
DAF	=	Dermal absorption factor (unitless)	Chemical-specific	Chemical-specific
EF	=	Exposure frequency (days/year)		
		Commercial Worker	250[d]	250[d]
		Utility/Excavation Worker	9[d]	9[d]
		Resident – Adult/Child	350[d]	40[d]
ED	=	Exposure duration (years)		
		Commercial Worker	25[d]	6[d]
		Utility/Excavation Worker	1[d]	0.5[d]
		Resident – Adult	30[d]	9[d]
		Resident – Child	6[d]	6[d]
CF	=	Conversion factor (kg/mg)	10^{-6}	10^{-6}
BW	=	Body weight (kg)		
		Adult	70[d]	70[d]
		Child	15[d]	15[d]
AT_{carc}	=	Averaging time for carcinogens (days)	25,550[d]	25,550[d]
AT_{non}	=	Averaging time for noncarcinogens (days)	ED (years) x 365 days/year[d]	ED (years) x 365 days/year[d]

Data\Jobs\Port of Portland\15191-00 T-1 Risk Assessment [Table2Derm(T1)]

Notes:

[a] LADD Lifetime absorbed daily dose, intake value used to evaluate potential carcinogenic effects. For the residential evaluation, the adult and child intakes will be combined as recommended in Appendix A, Section A.0 of DEQ guidance (2000).

[b] ADD Absorbed daily dose, intake value used to evaluate potential noncarcinogenic effects.

[c] UCL_{90} An upper one-sided 90 percent confidence limit of the mean or the maximum concentration (whichever is lower) will be used for the RME.

[d] DEQ (December 2000).

RME Reasonable maximum exposure; CT Central Tendency

Table 3 - Exposure Dose Equations and Exposure Factor Values
Inhalation of Volatiles
Terminal 1 South Risk Assessment Work Plan
Portland, Oregon

$$LADD^{a}\ (mg/kg\text{-}d) = \frac{C_{air} \times IR \times EF \times ED}{BW \times At_{carc}}$$

$$ADD^{b}\ (mg/kg\text{-}d) = \frac{C_{air} \times IR \times EF \times ED}{BW \times At_{non}}$$

Exposure Factor (units)	RME Value	CT Value
C_{air}[d] = Chemical concentration in air (mg/m^3)	UCL_{90}[c]	Arithmetic Mean
IR = Inhalation rate (m^3/day)		
Commercial Worker	15.2[e]	15.2[e]
Utility/Excavation Worker	15.2[e]	15.2[e]
Resident – Adult	15.2[e]	15.2[e]
Resident – Child	8.3[e]	8.3[e]
EF = Exposure frequency (days/year)		
Commercial Worker	250[e]	250[e]
Utility/Excavation Worker	9[e]	9[e]
Resident – Adult/Child	350[e]	350[e]
ED = Exposure duration (years)		
Commercial Worker	25[e]	6[e]
Utility/Excavation Worker	1[e]	0.5[e]
Resident – Adult	30[e]	9[e]
Resident – Child	6[e]	6[e]
BW = Body weight (kg)		
Adult	70[e]	70[e]
Child	15[e]	15[e]
AT_{carc} = Averaging time for carcinogens (days)	25,550[e]	25,550[e]
At_{non} = Averaging time for noncarcinogens (days)	ED (years) x 365 days/year	ED (years) x 365 days/year

Data\Jobs\Port of Portland\15191-00 T-1 Risk Assessment [Table3Inhal(T1)]

Notes:

[a] LADD Lifetime average daily dose, intake value used to evaluate potential carcinogenic effects. For the residential evaluation, the adult and child intakes will be combined as recommended in Appendix A, Section A.0 of DEQ guidance (2000).

[b] ADD Average daily dose, intake value used to evaluate potential noncarcinogenic effects.

[c] UCL_{90} Upper one-sided 90 percent confidence limit of the mean or the maximum concentration (whichever is lower) will be used for the RME.

[d] C_{air} will be derived from soil and groundwater concentrations using models discussed in DEQ guidance (1999 and 2000).

[e] DEQ (December 2000).

RME Reasonable maximum exposure; CT Central Tendency

Table 4 - Exposure Dose Equations and Exposure Factor Values
Inhalation of Dust
Terminal 1 South Risk Assessment Work Plan
Portland, Oregon

$$LADD^{a}\ (mg/kg\text{-}d) = \frac{PM_{10} \times IR \times EF \times ED}{BW \times At_{carc}}$$

$$ADD^{b}\ (mg/kg\text{-}d) = \frac{PM_{10} \times IR \times EF \times ED}{BW \times At_{non}}$$

Exposure Factor (units)	RME Value	CT Value
PM_{10}[d] = Respirable particulate concentration in air (mg/m^3)	UCL_{90}[c]	Arithmetic Mean
IR = Inhalation rate (m^3/day)		
Commercial Worker	15.2[e]	15.2[e]
Utility/Excavation Worker	15.2[e]	15.2[e]
Resident – Adult	15.2[e]	15.2[e]
Resident – Child	8.3[e]	8.3[e]
EF = Exposure frequency (days/year)		
Commercial Worker	250[e]	250[e]
Utility/Excavation Worker	9[e]	9[e]
Resident – Adult/Child	350[e]	350[e]
ED = Exposure duration (years)		
Commercial Worker	25[e]	6[e]
Utility/Excavation Worker	1[e]	0.5[e]
Resident – Adult	30[e]	9[e]
Resident – Child	6[e]	6[e]
BW = Body weight (kg)		
Adult	70[e]	70[e]
Child	15[e]	15[e]
AT_{carc} = Averaging time for carcinogens (days)	25,550[e]	25,550[e]
At_{non} = Averaging time for noncarcinogens (days)	ED (years) x 365 days/year	ED (years) x 365 days/year

Data\Jobs\Port of Portland\15191-00 T-1 Risk Assessment [Table4InhalT1)]

Notes:

[a] LADD Lifetime average daily dose, intake value used to evaluate potential carcinogenic effects. For the residential evaluation, the adult and child intakes will be combined as recommended in Appendix A, Section A.0 of DEQ guidance (2000).

[b] ADD Average daily dose, intake value used to evaluate potential noncarcinogenic effects.

[c] UCL_{90} Upper one-sided 90 percent confidence limit of the mean or the maximum concentration (whichever is lower) will be used for the RME.

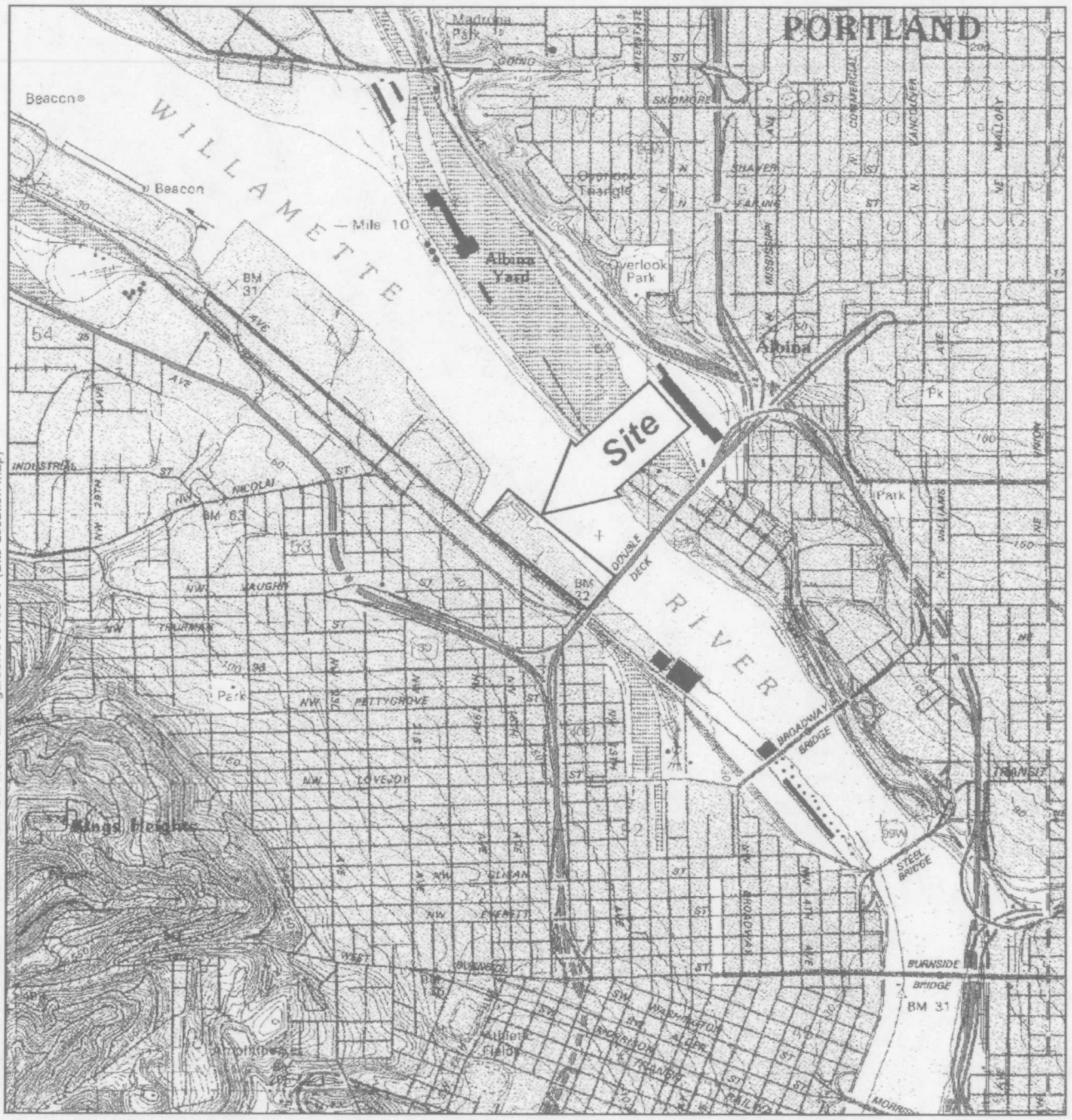
[d] PM_{10} will be derived using the Particulate Emission Factor equation presented in DEQ guidance (2000).

[e] DEQ (December 2000).

RME Reasonable maximum exposure; CT Central Tendency

Site Location Map

Terminal 1 South Risk Assessment, Work Plan
Port of Portland, Portland, Oregon



Data\Jobs\Port of Portland\15191-00 T-1 Risk Ass. Work Plan\Figures\1519100 01 (Site Location Map)

Note: Base map prepared from the USGS 7.5-minute quadrangle of Portland, OR dated 1990.

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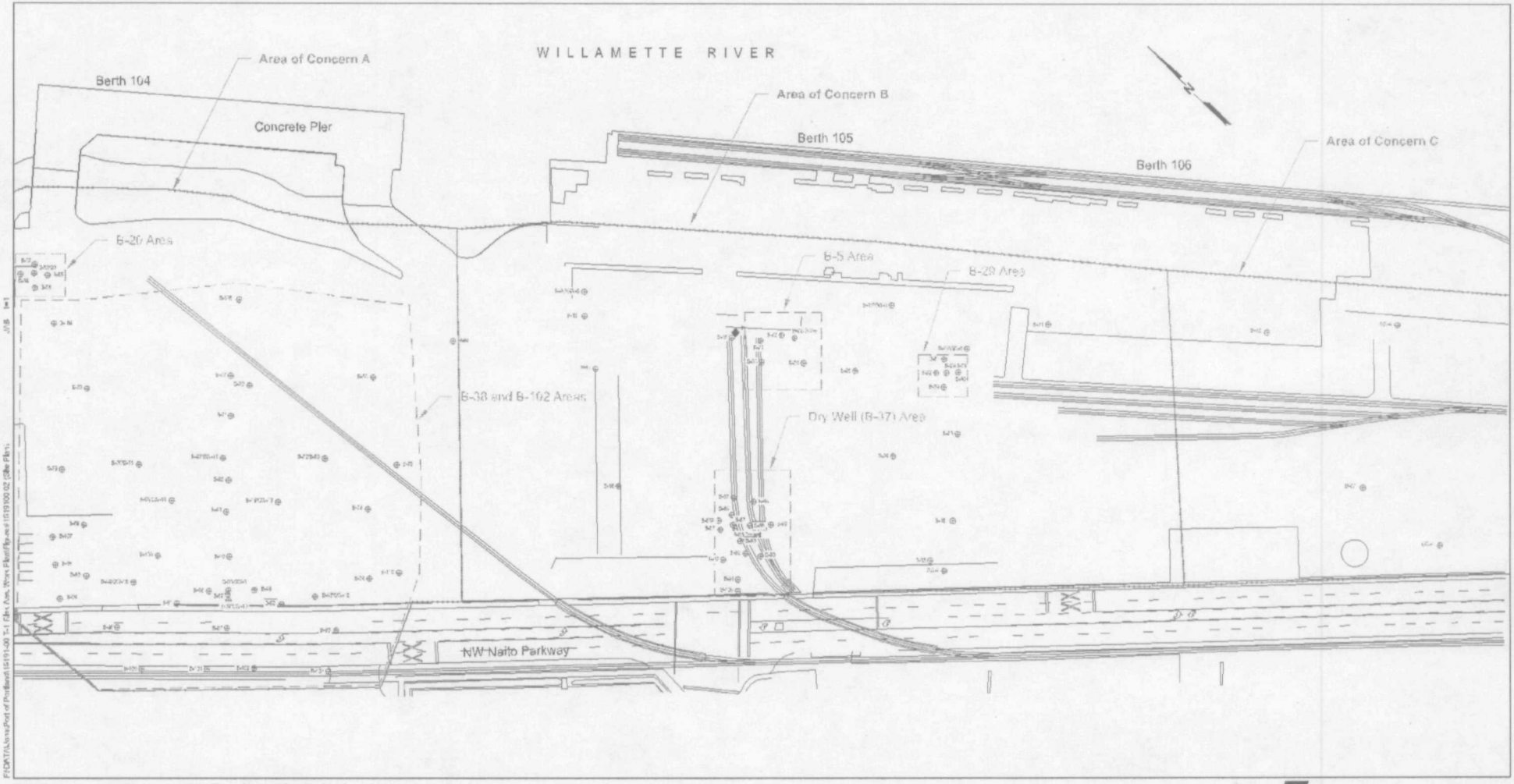
15191 *10/01*

Figure 1

Site Plan
Terminal 1 South Risk Assessment, Work Plan
Port of Portland, Portland, Oregon



Note: Base map prepared from an AutoCAD file provided by Olson Engineering, 8/27/01.

Legend:

Maul Foster and Alongi, Inc. Push Probe Boring Location and Number (March 1998)

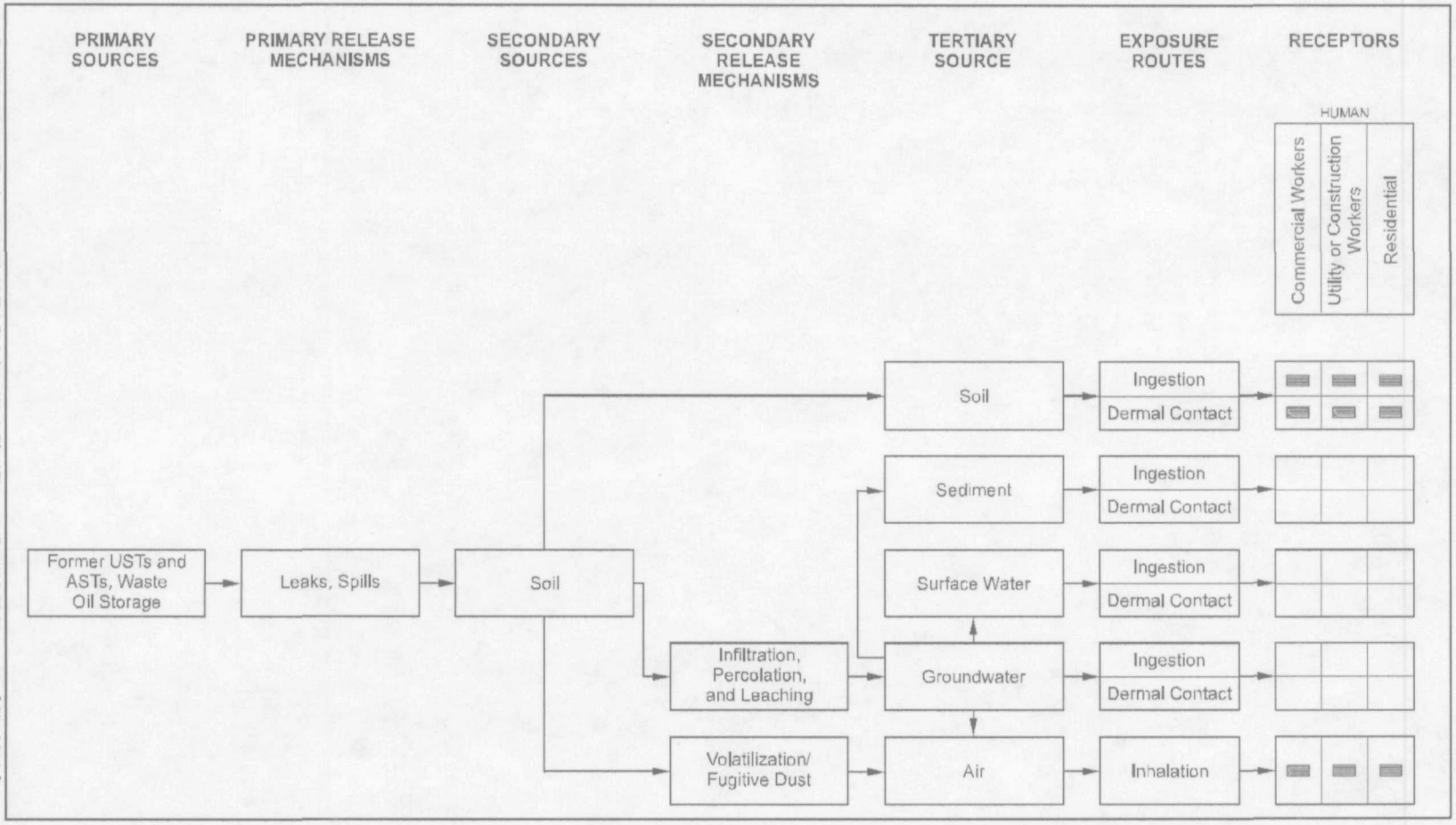
HAI Push Probe Boring Location and Number (2000)

0 100 200
Approximate Scale in Feet

HARTCROWSER
15191-00 *10/01*
Figure 2

POPT1S604933

Human Health Conceptual Site Model
Terminal 1 South Risk Assessment, Work Plan
Port of Portland, Portland, Oregon



Data\Jobs\Port of Portland\15191-00 T-1 Risk Ass. Work Plan\Figures\15191003 (Conceptual Site Model)

15191
Figure 3
10/01

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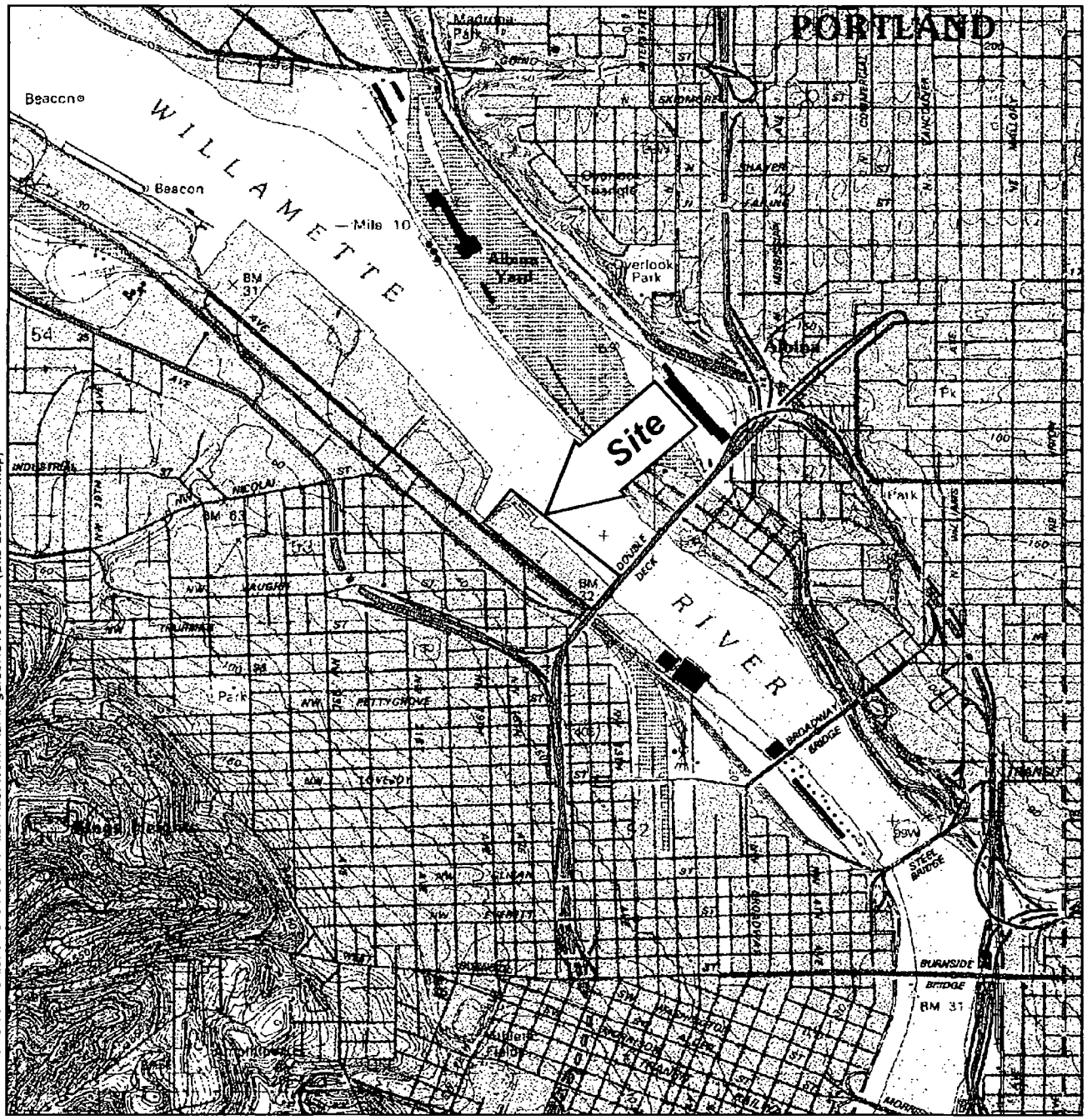
Legend:

Potentially Complete Pathway

POPT1S604934

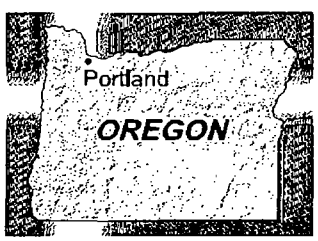
Site Location Map

Terminal 1 South Risk Assessment, Work Plan
Port of Portland, Portland, Oregon



DataJobs\Port of Portland\15191-00 T-1 Risk Ass. Work Plan\Figures\1519100 01 (Site Location Map)

Note: Base map prepared from the USGS 7.5-minute quadrangle of Portland, OR dated 1990.



0 2,000 4,000

Scale in Feet
Contour Interval 10 Feet

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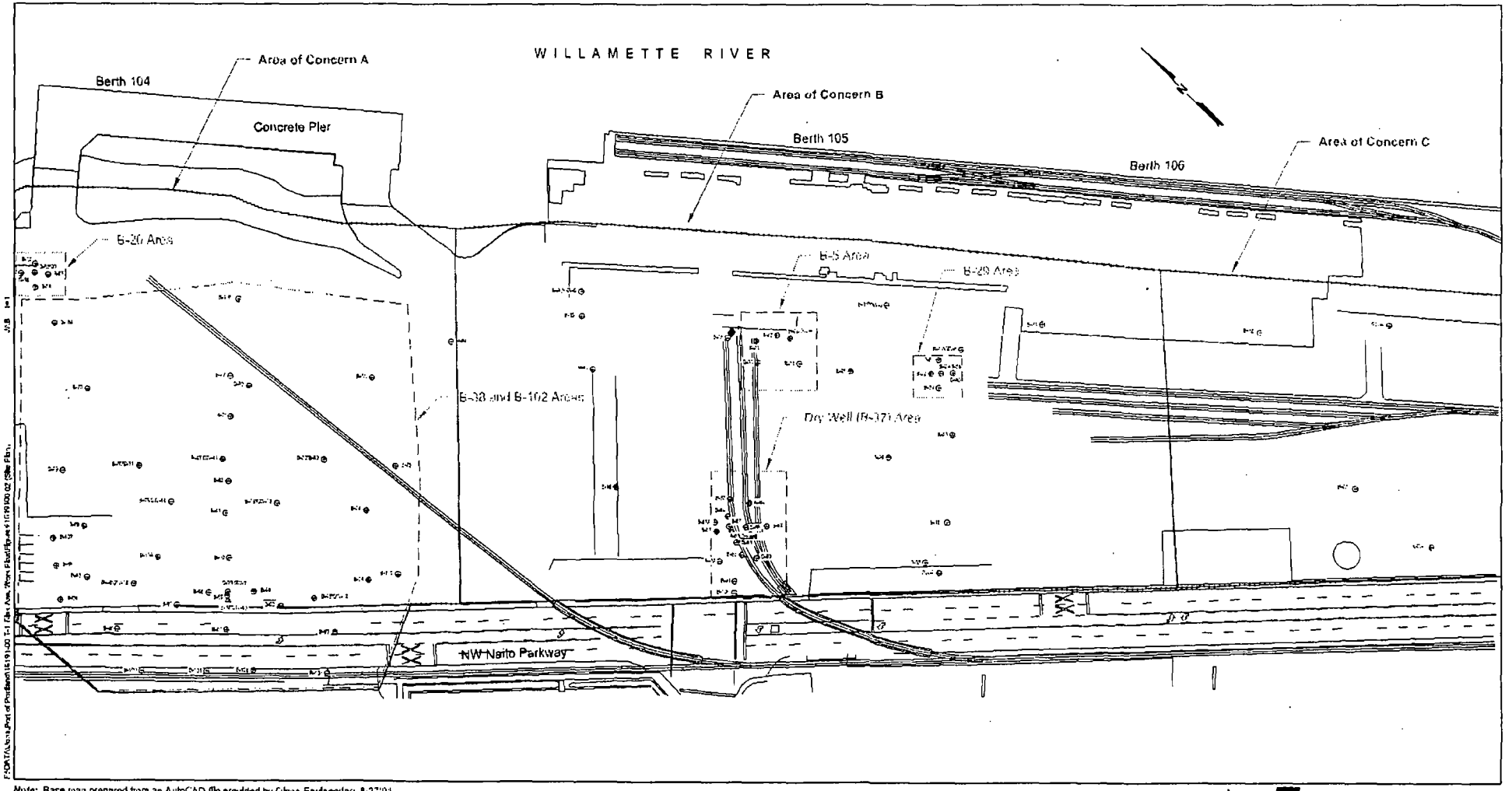
15191 *10/01*

Figure 1

Site Plan
Terminal 1 South Risk Assessment, Work Plan
Port of Portland, Portland, Oregon



Note: Base map prepared from an AutoCAD file provided by Gibson Engineering, 8/27/01.

Legend:

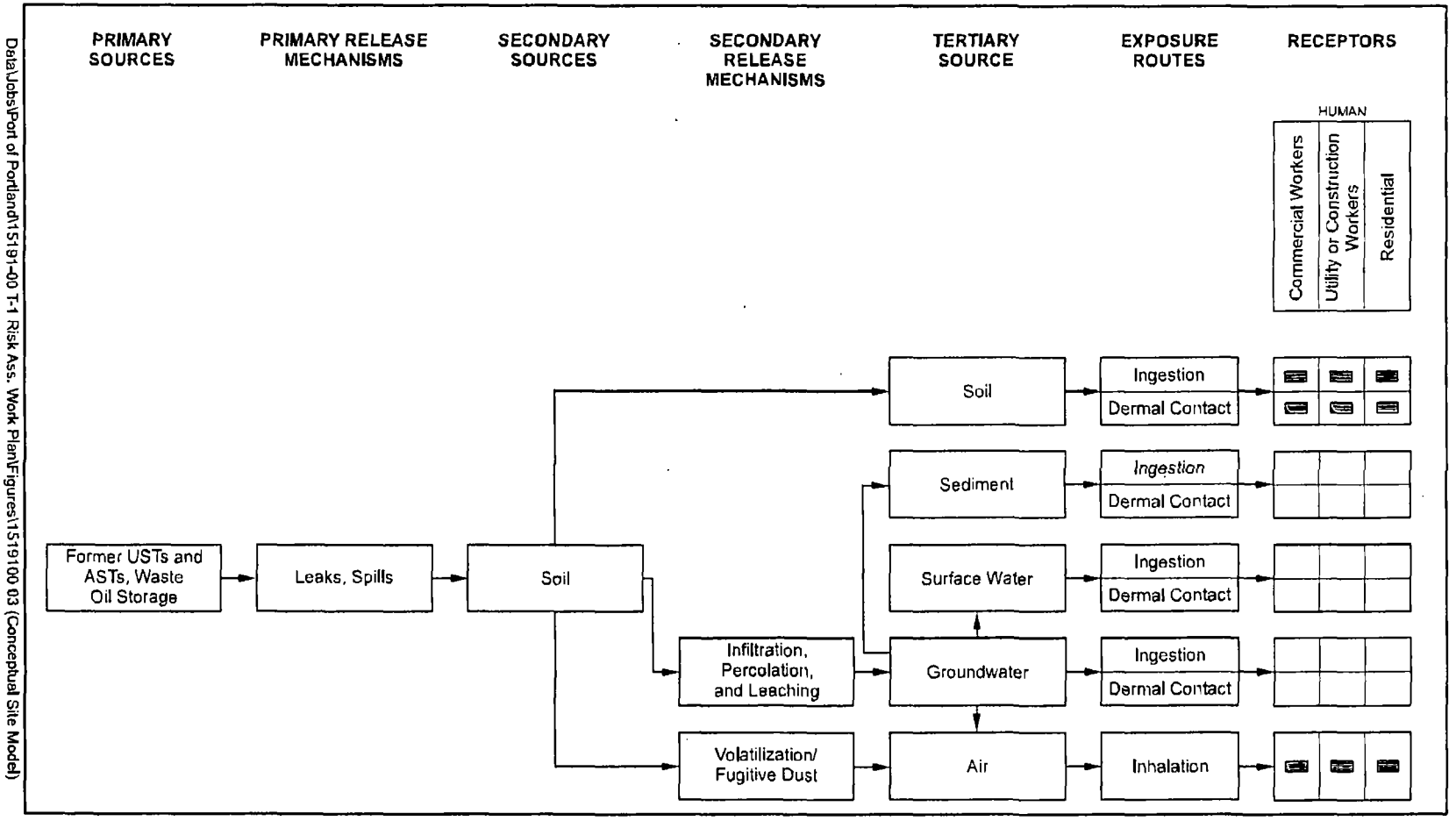
Maul Foster and Alongi, Inc. Push Probe Boring Location and Number (March 1998)

HAI Push Probe Boring Location and Number (2000)

0 100 200
Approximate Scale in Feet

HARTCROWSER
15191-00 *10/01*
Figure 2

Human Health Conceptual Site Model
Terminal 1 South Risk Assessment, Work Plan
Port of Portland, Portland, Oregon



Legend:

Potentially Complete Pathway

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15191
Figure 3
10/01

Data\Jobs\Port of Portland\15191-00 T-1 Risk Ass. Work Plan\Figures\15191003 (Conceptual Site Model)

POPT1S604934